

AMENDMENTS TO THE DRAWINGS:

The attached drawing sheet includes changes to Figure 1. This sheet, which includes Figure 1, replaces the original sheet including Figure 1. Figure 1 was amended to label the active material 14. No new matter is believed to be added.

Attachment: Replacement Sheet

REMARKS

The amendment to the claims and drawings are expected to require further consideration and/or search.

Accordingly, a Request for Continued Examination is filed with this amendment.

The application is amended in a manner to place it in condition for allowance at the time of the next Official Action.

Status of the Claims

Claim 11 has been amended to clarify that the plasma treatment uses one of listed gases, as well as to specify the linear mobility of the transistor consistent with the specification as filed at paragraphs [0009], [0054], [0068] and [0069].

Claims 11, 15-17 and 24 are amended as to form.

Claims 18 and 19 have been cancelled without prejudice.

Claims 1-11, 14-17, 20, 21 and 23-27 remain pending.

Claims 1-10, 20 and 21 have been withdrawn for being directed to a non-elected invention.

Objection to the Drawings

The drawings were objected to for not illustrating a top gate transistor.

Although such a transistor is believed to be readily apparent to one of ordinary skill in the art in view of the

present specification and Figure 1, claims 18 and 19 are cancelled, without prejudice, to place the application in condition for allowance.

The Official Action also objected to the recitation that the active material and electrodes are formed on top of the substrate (i.e., under written description). This is believed to be apparent from page 5 of the specification at lines 16-25 and Figure 1. That is, the active material and electrodes 2 are described as being formed, and in looking to Figure 1, active material and electrodes 2 are located above the substrate and below the insulator 3. Although no particular number is associated with the active material, in view of the different shading between the electrode and substrate, it is believed to be clear that this different shading is the active material, which has now been labeled in Figure 1.

No new matter is believed to have been added by this amendment to Figure 1.

Thus, withdrawal of the objection is respectfully requested.

Claim Objections

Claims 11, 15-17 and 24 were objected because of informalities.

Applicant acknowledges with appreciation the Examiner's helpful suggestions to overcome the objection, e.g., using

consistent terminology. These suggestions have been incorporated into the claims.

Thus, withdrawal of the objection is respectfully suggested.

Claim Rejections-35 USC §112, 1st paragraph

Claims 11, 14-19 and 23-27 were rejected under 35 U.S.C. §112, for not complying with the written description requirement. This rejection is respectfully traversed.

The Official Action noted that recitation of "forming an insulator on top of said active material and electrodes" in claim 11 was not described in the specification (see fig. 1 & page 5, lines 16-35), but instead, that the insulator is formed above the gate electrode formed on the substrate.

However, the active material and electrodes 2 are described on page 5 as being formed, and in looking to Figure 1, active material and electrodes 2 are located above the substrate and below the insulator 3. Although no particular number is associated with the active material, in view of the different shading between the electrode and substrate, it is believed to be clear that this different shading is the active material, which has now been labeled in Figure 1.

Therefore, withdrawal of the rejection is respectfully requested.

Claim Rejections-35 USC §112, 2nd paragraph

Claims 17 and 19 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite. This rejection is respectfully traversed.

Claim 19 has been cancelled.

The term "flux" in claim 17 was considered unclear. However, as the claim refers to chemical elements generating a flux in reference to deposition of an element in claim 11, it is believed to be understood that the flux corresponds to the rate of deposition.

Therefore, withdrawal of the rejection is respectfully requested.

Claim Rejections-35 USC §103

Claims 11, 14-19 and 23-27 were rejected under 35 U.S.C. §103(a) as being unpatentable over NAKATA U.S. 6,078,059 ("NAKATA") in view of ROCA et al. ("ROCA") and YOSHINOUCHI et al. US 5,403,756 ("YOSHINOUCHI"). This rejection is respectfully traversed for the reasons below.

NAKATA

NAKATA describes a method for producing a thin film transistor comprising the steps of (Col 8 L. 53 - Col 9 L. 16):

- depositing an insulating thin film of silicon nitride (Si_3N_4) obtained by plasma discharge in a gaseous mixture of

three gases: monosilane (SiH_4), ammonia (NH_3) and hydrogen (H_2), and

- depositing a polycrystalline silicon layer obtained by alternating deposition of a thin silicon layer (Si) and exposure to a hydrogen plasma (H_2).

NAKATA discloses forming an insulating Si_3N_4 layer using a plasma discharge in a gaseous mixture containing ammonia (NH_3) mixed with silane (SiH_4) and hydrogen (H_2).

According to the Official Action, NAKATA would thus disclose (implicitly) a plasma treatment of the top surface of the insulating Si_3N_4 layer with an ammonia (NH_3) plasma (wherein ammonia belongs to the group consisting of N_2 , O_2 , N_2O and NH_3 according to claim 11). The Si_3N_4 layer of the transistor in NAKATA comprises a SiN_x type interface with the microcrystalline silicon layer deposited onto the Si_3N_4 layer.

The Official Action recognizes that NAKATA does not describe a process enabling to obtain a microcrystalline silicon layer having a crystalline fraction above 80%.

However, since the polycrystalline silicon layer of the transistor of NAKATA has a crystalline fraction below 70%, the linear mobility of the transistor is necessarily limited, and in any case below $1.5 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$.

In NAKATA, the NH_3 gas is not used alone for treating

the surface of the Si₃N₄layer, but NH₃ gas is always diluted with SiH₄ and H₂ for depositing an insulating Si₃N₄layer (Col 8, L. 61-Col 9 L.2).

On the contrary, the claimed process differs from NAKATA in that it comprises a step of plasma treatment of the top surface of the insulating layer, before deposition of the microcrystalline silicon film, said plasma surface treatment comprising only a gas selected from N₂, O₂, N₂O and NH₃. In other words, according to the claimed invention, the gas used for plasma treatment of the insulating layer top surface is not mixed with another gas such as silane (SiH₄).

The effect of the plasma treatment using a pure NH₃ plasma treatment (or a plasma of N₂, O₂, N₂O) is to reduce nucleation sites at the surface of the insulating layer onto which is deposited the microcrystalline layer (see [0054]). The process according to the invention thus enables one to obtain a microcrystalline layer having a crystalline fraction above 80 % and a transistor having a linear mobility equal or superior to 1.5 cm²V⁻¹s⁻¹ (claim 11).

In contrast, the process of NAKATA drives to producing a microcrystalline silicon layer which crystalline fraction is limited below 70% and a transistor having linear mobility much lower than 1.5 cm²V⁻¹s⁻¹.

ROCA

ROCA is admitted prior art of the present patent application.

ROCA discloses a process for producing a "top gate" transistor comprising deposition of a microcrystalline silicon film using the "layer-by-layer" technique by alternating a deposition plasma for forming an a-S:H layer and a hydrogen plasma treatment, for obtaining a microcrystalline silicon film with a crystalline fraction that can exceed 80%. According to ROCA, the microcrystalline silicon film is deposited either onto glass (SiO_2) or onto a semiconducting a-Si:H layer.

However, ROCA does not disclose a plasma treatment of the interface onto which a microcrystalline silicon film is deposited. More precisely, ROCA does not disclose a plasma treatment of the interface of an insulating layer onto which a microcrystalline silicon film is deposited, said plasma treatment being an of N_2 , O_2 , N_2O or NH_3 plasma treatment.

The linear mobility of the transistors obtained by the different embodiments of ROCA remains below $0.64 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$, although the crystalline fraction of microcrystalline silicon is higher than 80%.

The Proposed Combination

NAKATA discloses a process for producing a microcrystalline silicon film deposited on an insulating Si₃N₄ layer, wherein the crystalline fraction of the microcrystalline silicon layer is lower than 70%. The Si₃N₄ layer is obtained by plasma discharge in a gas mixture containing silane, hydrogen and ammonia (NH₃). The interface onto which is later deposited the microcrystalline silicon of the Si₃N₄ type.

ROCA discloses a process for producing thin film transistors based on micro- or poly-crystalline films having a high crystalline fraction (80-90%). In the examples of ROCA, microcrystalline silicon is deposited either on a semiconducting a-Si:H layer or on glass (SiO₂). The linear mobility of the transistor of ROCA reaches at best 0.64 cm²V⁻¹s⁻¹.

Desiring to improve the performances of the transistor of NAKATA, the person skilled in the art may try applying the process of ROCA which enables improving the crystalline fraction of the microcrystalline film, but does not allow to improve sufficiently the transistor linear mobility, which remains limited to below 0.64 cm²V⁻¹s⁻¹.

However, neither ROCA nor NAKATA discloses the treatment of an insulating layer using a plasma formed using a gas selected from the group consisting of N₂, O₂, N₂O and NH₃, for treating the interface onto which microcrystalline silicon is deposited.

Applying the process of ROCA for producing a microcrystalline silicon layer on an insulating Si_3N_4 layer as obtained following the process disclosed in NAKATA, does not lead to the process of claim 11.

As demonstrated in the examples of the present application, only a plasma treatment formed using a gas selected from the group consisting of N_2 , O_2 , N_2O and NH_3 , enables one to treat the interface of the insulating layer onto which is deposited the microcrystalline silicon, which appears to be essential for improving the linear mobility of the transistor :

- in ROCA, without plasma treatment of the interface onto which microcrystalline silicon is deposited, the transistor linear mobility is below $0.64 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$ (see ROCA Table II) ;
- according to the present patent application ([0067]), treatment of a SiN_x layer with an Argon plasma (and not a plasma of N_2 , O_2 , N_2O and NH_3), and then depositing a microcrystalline layer using a plasma in a mixture of SiF_4 - Ar-H_2 produces a transistor having a linear mobility below $0.02 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$;
- in contrast, according to an embodiment of the claimed invention ([0068]), plasma treatment of an SiN_x layer using an N_2 plasma and then deposition of a microcrystalline film using a plasma in a mixture of SiF_4 - Ar-H_2 enables one to obtain a transistor having a linear mobility reaching $3 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$.

The effect of the specific plasma treatment of the interface of the insulating layer on top of which the microcrystalline film is deposited, said plasma treatment using a gas selected from the group consisting of N₂, O₂, N₂O and NH₃ is thus to improve considerably the linear mobility of the transistor, so that it reaches at least 1.5 cm²V⁻¹s⁻¹. (See [0009], [0054], [0068] and [0069] of the application as filed.)

None of the cited documents suggests such a plasma treatment. The claimed invention does not derive obviously from the state of the art.

Therefore, withdrawal of the rejection is respectfully requested.

Conclusion

In view of the amendment to the claims and the foregoing remarks, this application is in condition for allowance at the time of the next Official Action. Allowance and passage to issue on that basis is respectfully requested.

Should there be any matters that need to be resolved in the present application, the Examiner is respectfully requested to contact the undersigned at the telephone number listed below.

The Commissioner is hereby authorized in this, concurrent, and future submissions, to charge any deficiency or credit any overpayment to Deposit Account No. 25-0120 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17.

Respectfully submitted,

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APPENDIX:

The Appendix includes the following item:

- a Replacement Sheet for Figure 1 of the drawings